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PROGRESS REPORT ON THE EFFECT OF FREQUENT FIRES ON THE FERTILITY OF FOREST SOILS ON THE LONGLEAF PINE REGION OF THE SOUTHEAST.

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May 23 1933.

E.B.

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PROGRESS REPORT ON THE EFFECT OF FREQUENT FIRES ON THE FERTILITY OF FOREST SOILS ON THE LONGLEAF PINE REGION OF THE SOUTHEAST*

One of the most important problems confronting forestry in the Southern pine region is fire. Within this region annual fires are frequent, being set principally by members of two groups, namely, cattlemen and naval stores operators. It is the belief of the cattlemen that the natural range is improved by burning the woods because of the stimulated growth of the herbaceous vegetation on which the cattle graze. Likewise, the naval stores operators favor fires because, when set during periods of poor burning conditions, fires do no great damage to timber which is being worked for turpentine, and the risk of the occurrence of a later fire is practically eliminated until the following year. It is the practice in the naval stores region to rake all combustible material such as grass and pine needles from the base of each tree being turpentined. The trees, each of which is thus protected by an individual fire line, do not appear to be materially injured when the area is burned carefully. Moreover, fires remove underbrush, and this facilitates all phases of the woods work.

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* R. M. Barnette of the Florida Agricultural Experiment Station conducted the laboratory work, and F. Heyward of the Southern Forest Experiment Station was in charge of the field work.

E. E.

Numerous studies have been made by the foresters on the influence of fires on tree growth. But little investigation has, however, been directed to the effect of fire on the soil. For years popular writings of foresters and conservationists have decried woods burning citing as one of its attending evils the impoverishment of the soil. It has been claimed that, through the decomposition of forest litter, a constant supply of organic matter is added to the soil. The removal of this material by fire is said to be accompanied by a reduction of soil fertility. No data supporting this idea have been cited, it being believed that the sequence and occurrence of these conditions were so logical that actual proof of their veracity was not necessary.

Because of the widespread practice in the South of burning the woods annually, it appears desirable to study the effect of frequent fires on the chemical composition of representative soils of the region. With this in mind the present study was undertaken.

DESCRIPTION OF REGION STUDIED

Collection areas were located from South Carolina through the intervening states to Louisiana. All the soils sampled were within the Coastal Plain. Topography varied from level to slightly hilly. A wide range in drainage and texture of soils was encountered. For this reason the soils which were sampled have been divided as follows: (1) Excessively drained deep sands, (2) well drained sands, (3) moist sands, (4) poorly drained sands, (5) and sandy or silt loams. The soils of the first division are sands 8 feet or more in depth, with a

water table many feet below the soil surface. They are characterized by a sparser, more xerophytic vegetative cover than the remaining soils. The second class differs from the preceding by having a much more shallow water table and usually a sandy clay subsoil at a depth of about six feet. These soils are, therefore, somewhat more moist throughout most of the year than those of group 1. Group 3 soils are more moist than those of the preceding groups and the soils are slightly more loamy. These three groups are characterized by flat to gently rolling topography. Groups 1 and 2 are essentially longleaf pine soils, being too dry for the natural occurrence of slash. Group 3 soils are sufficiently moist for slash pine to establish itself naturally, provided no fires occur. Group 4 soils are the poorly drained soils of the flat-woods. The soils of group 5 are much heavier in texture than those of the other groups. Within this group drainage varies from poor, area 15, to good, area 13. A description of the underbrush and general type of ground cover for each separate area is given in the appendix.

The soils are divided into these arbitrary groups as it was believed that, because of their widely divergent characteristics, members of one group might respond differently to frequent burning of the vegetation than those of another. The difference in drainage, topography, and vegetative cover, particularly the abundance of ground cover, would no doubt cause fires of varying intensity on the soils of the several respective arbitrary divisions. Thus it may be stated with certainty that the normal fires which occur on group 3 soils are hotter than those from group 1 soils, the difference being caused by the much greater amount of combustible material on these soils.

METHODS

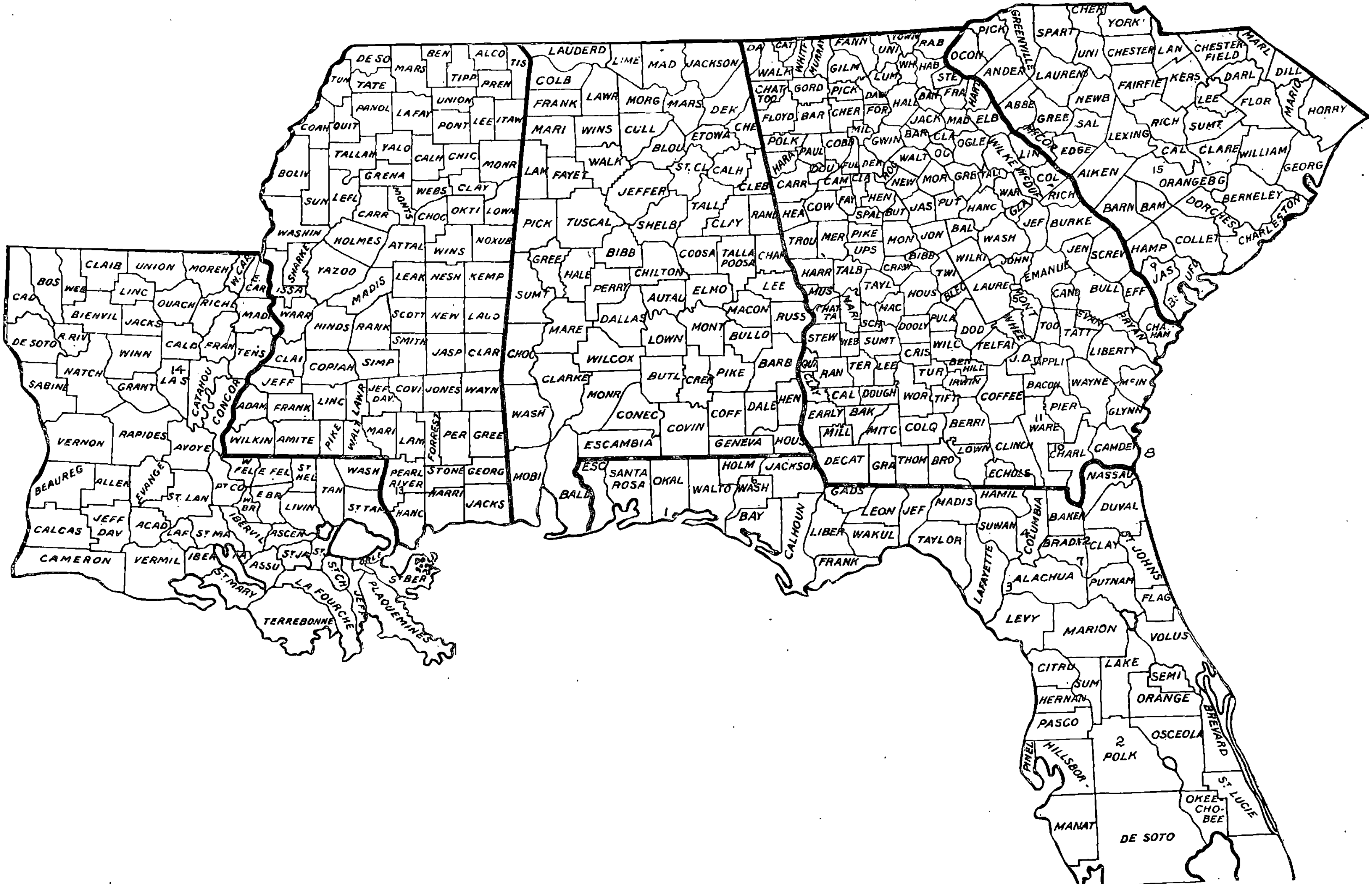
An extensive survey was made of as many long unburned stands of longleaf and slash pine as could be located. The study was confined to areas protected from fire for ten years or longer. The accompanying map shows the region covered. Over thirty long unburned stands of timber were located. These varied in area from one-half acre to several thousand acres. Of this number only fourteen were selected for study as no comparable burned areas could be found for the others. A detailed description of each study area is given in the appendix.

SELECTION OF STUDY AREAS.

In selecting the burned and unburned areas to be compared it was necessary to avoid as far as possible any variations between them except those caused by fire. It was highly desirable that the areas be adjacent as this would tend to eliminate any variations in the soil. Only areas I, IV and IX failed to meet this requirement. On area I the soils compared were one mile apart, on area IV approximately one hundred yards, and on area IX one-half mile. On all other study areas the burned and unburned soils were adjacent, being separated only by some artificial boundary such as fence or road.

Only soils of the same series and type were compared, and by carefully locating the exact area from which the soil samples were to be collected, variations in drainage and topography were eliminated as far as possible. After noting the characteristics of the burned and unburned

MAP SHOWING STUDY AREAS



soils to be compared and after finding them closely alike, samples were collected.

Sampling Technic

Collection of individual samples. Each individual sample was obtained as follows: The soil profile was exposed by digging a hole 15 inches square and from 20 to 30 inches deep depending on the soil type. If these profiles showed no signs of large decayed roots, deposits of charcoal, burrowing animals, or variations in color and texture, approximately 300 grams (half of the samples were of this amount and the remainder were about four times this amount) of soil were collected from each of three depths determined according to horizon. These were: (1) the A_1 horizon which was usually from 2 to 3 inches deep, (2) that portion of the A horizon at which the dark discoloration caused by organic matter faded out, usually 6 to 8 inches, and (3) a third depth which was well within the B horizon on the heavier soils but which was selected arbitrarily between 24 and 30 inches on the sandy types in which it is impossible to differentiate between the A and B horizons. The samples were placed in paraffined cardboard cartons for conveyance to the laboratory.

Number and Distribution of Samples: Three intensities of sampling were carried out. These were: (1) one composite of four individual samples from the burned and unburned portions of each of the fourteen study areas; (2) thirty individual samples from each portion of the Soperton, McNeil and Bartow areas; and (3) one hundred individual samples

from each portion of the Trenton area (Table I). Twelve individual samples from the Trenton area were also collected. These samples, originally collected for moisture determinations, were also analyzed chemically.

The composite sample was prepared by placing the four samples from each respective horizon in a sheet of canvas and rollong to accomplish thorough mixing. After the first mixing the soil was divided into halves, one of which was discarded and the other remixed. One half of this was discarded and the other remixed. One half of this was discarded and the remainder retained for analysis. The profiles sampled were 30 to 60 feet apart.

Following the completion of the analyses of the samples mentioned above, the collections of the thirty individual samples were made. The profiles from which the samples were obtained were distributed as uniformly as practicable over a square plot approximately one-quarter acre in extent. For the ~~Adrian~~ Soperton area the collection plots were about one-half acre in size. Only the A_1 horizon was sampled in this phase of the work.

After the completion of the analyses of the thirty samples for the three above areas, the Trenton area was re-sampled in even greater detail. One hundred individual samples were collected from the burned and unburned portions. The collection area for each portion was 60 feet square and the samples were checkerboarded over this area at regular intervals of 6.6 feet, the A_1 horizon only being sampled.

TABLE 1

NUMBER OF SAMPLES AND DATE OF COLLECTION FOR EACH STUDY AREA.

Study area number	Location	Arbitrary soil division	Number of samples from each burned and unburned plot.	Date sampled
I	Choctawhatchee National Forest, Florida.	Excessively drained deep sands	1 composite *	April 12, 1931.
II	Bartow, Florida	" " "	1 composite 30 individuals	March 23, 1931 April 20, 1932
III	Trenton, Florida	Well drained sands	2 composites 12 individuals 100 individuals	Oct. 26, 1931 Oct. 26, 1931 Aug. 30, 1932
IV	Lake City, Florida	" " "	1 composite	Dec. 17, 1931
V	Soperton, Ga.	" " "	1 composite 30 individuals	Feb. 12, 1931 May 24, 1932
VI	Chipley, Florida	Moist sands	1 composite	Nov. 9, 1931
VII	Raiford, Florida	" "	1 composite	Dec. 15, 1931
VIII	Cumberland Island, Ga. (unburned area)	" "	1 composite	Dec. 4, 1931
IX	Ridgeland, S. C.	" "	1 composite	Feb. 4, 1931
X	Racepond, Georgia	Poorly drained sands	1 composite	Feb. 20, 1931
XI	Waycross, Ga.	" " "	1 composite	Feb. 23, 1931
XII	Starke, Florida	" " "	1 composite	Jan. 21, 1931
XIII	McNeil, Miss.	Sandy and silt loams	1 composite 30 individuals	Nov. 5, 1931 May 5, 1932
XIV	Urania, Louisiana	" " " "	1 composite*	Nov. 3, 1931
XV	Summerville, S. C.	" " " "	1 composite	Feb. 6, 1931

* All composites of four individual samples

Chemical Analyses

Each soil sample was given a permanent number after arrival at the laboratory. Its identity and source remained unknown until the results of the analyses were being tabulated. For the composite samples tests were made according to standard methods for total nitrogen, total carbon, loss on ignition, hygroscopic moisture, replaceable calcium, replaceable magnesium, and hydrogen ion concentration (see "Analytical Methods" in appendix). Only total nitrogen, loss on ignition and hygroscopic moisture determinations were made for the thirty and one hundred individual samples. All chemical analyses were performed in duplicate. The results here reported are averages of duplicate determinations.

For soils low in carbonates and colloidal materials the loss on ignition test is considered a reliable index of the organic matter. Hygroscopic moisture is also an index of organic matter and was determined to supplement the loss on ignition values. Total nitrogen should not be confused with nitrogen in a form useable by the higher plants. However, the assumption was made that the greater the content of total nitrogen the greater would be the quantity of useable nitrogen for any particular soil. Hence in this work a soil having a higher total nitrogen content than another is also regarded as being more fertile. The carbon-nitrogen ratio in soils is of importance in showing the relative stage of decomposition of the organic matter and also in determining the type of biological activity which may occur. For this reason tests for total carbon were made. *

The C : N ratio of the soils reported at this time will be discussed in a separate report.

Tests for replaceable calcium and magnesium were made to determine whether the addition of ash following fire was a noticeable factor in the fertility of burned and unburned soils.*

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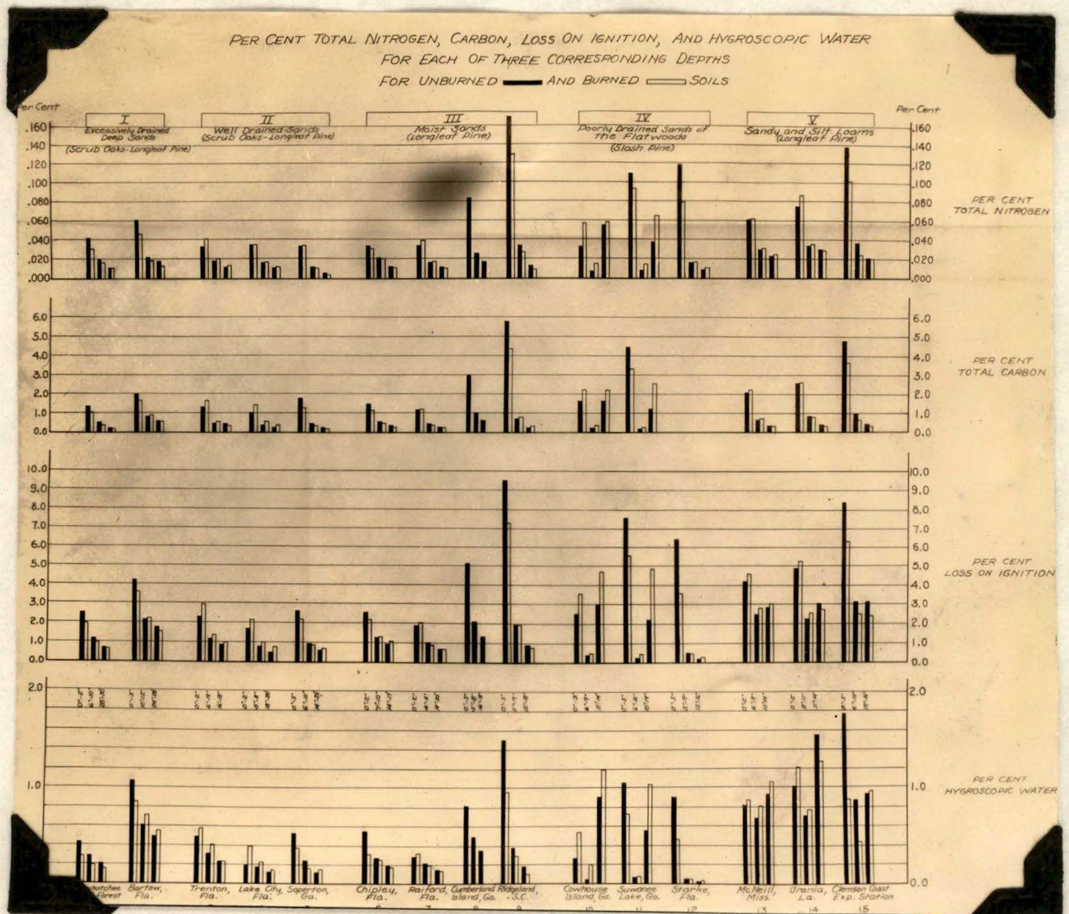
* The soils from areas subjected to frequent fires will for convenience be designated hereafter as "burned soils"; likewise, the soils from areas on which no fires have occurred for many years will be referred to as "unburned soils".

Mechanical Analyses

Approximate mechanical analyses were made by Bouyoucos' hydrometer method to determine the comparability of the soils studied from a physical standpoint.



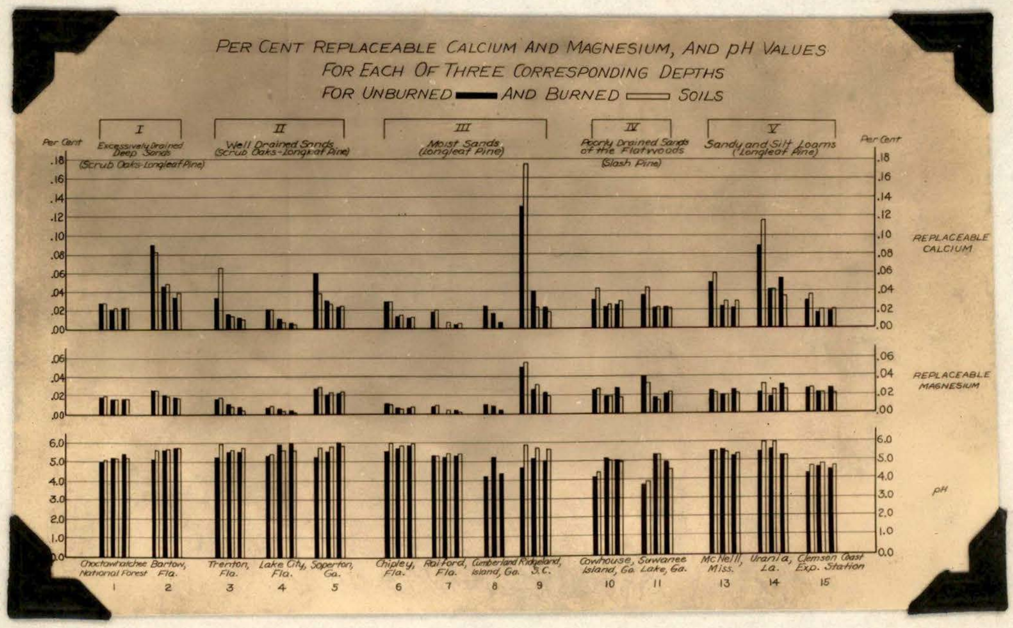


Figure I

Based on figures in Table IX.

TABLE II *

SUMMARY OF CHEMICAL ANALYSES OF THE 4-SAMPLE COMPOSITES

Chemical analysis	Soil depth	Greater on unburned	Greater on burned	No difference
		Number of areas	Number of areas	Number of areas
Total nitrogen	1st	4	4	5
	2nd	2	4	7
	3rd	3	1	9
Total carbon	1st	7	4	2
	2nd	6	6	1
	3rd	8	4	1
Loss on ignition	1st	7	6	0
	2nd	4	7	2
	3rd	5	7	1
Hygroscopic moisture	1st	7	5	1
	2nd	5	2	6
	3rd	2	4	7
Replaceable calcium	1st	2	8	3
	2nd	3	2	5
	3rd	3	4	6
Replaceable magnesium**	1st	1	1	11
	2nd	2	2	8
	3rd	6	1	6
pH values	1st	0	10	3
	2nd	3	7	3
	3rd	4	6	3

* Summarized form of Table X in appendix. Areas 8 and 12 are not included in these tables as no burned portion was located on area 8, and only the means of duplicate tests were available for area 12.

** Data omitted for second depth of area 7.

RESULTS

Chemical Analyses of Soils from Burned and Unburned Areas.

The results of the chemical analyses of the four composite samples did not show consistent differences in the quantities of total nitrogen and organic matter in soils from burned and unburned areas; however, the percentage of replaceable calcium and the pH values of the first depth of the burned soils were consistently higher than for the soils not subjected to fire. The results are presented by individual areas in Figure I and Table II. In this table the data are summarized by a tally of the number of areas the chemical analyses of which favor in magnitude the burned and unburned plots as well as those which are neutral. If, for any test, the difference between the means of the composite samples was greater than the difference between duplicate determinations of any one sample *, the area was tallied in the "unburned" or "burned" column as the case might be. If, however, the difference between the means of the composites did not exceed the difference between duplicate determinations, the area was recorded under the column headed "no difference".

* It should be remembered that each chemical analysis was run in duplicate. The results of each analysis is, therefore, the mean value of duplicate determinations.

It is seen from Table II that the total number of unburned areas having greater quantities of nitrogen, carbon, and organic matter,

is about equalled by the number of burned areas. The results for replaceable calcium in the first soil depth, however, are fairly consistent in indicating a greater quantity in the soils of the burned areas. The pH values are even more consistent for this depth indicating less acid conditions on the burned areas. No differences are indicated for replaceable magnesium.

It should be noted that no consistent trends showing differences in chemical characteristics are indicated for the second or third depths of the soils being compared. Although there is a definite trend showing higher replaceable calcium and pH values for the first depth of the burned soils, no such trend is suggested for calcium and only a slight trend for pH at greater depths.

The results for nitrogen and organic matter obtained for the four-sample composites suggest two possible conditions in the soils from burned and unburned areas. These are: (1) no real differences in the quantity of these substances in the two classes of soils, or (2) if such differences do exist, they are too small when compared to the variation within each soil, to be consistently shown by analyses of composites of only four individual samples. To determine either of these conditions a more intensive sampling was necessary. In order to estimate the minimum number of samples required to bring out with accuracy any real differences in the burned and unburned soils it was necessary to obtain some measure of the variation to be expected within these soils. To obtain an estimate of this variation three representative areas were resampled, namely: (1) Bartow, McNeill, and Soperton. Thirty individual samples were collected

from each burned and unburned portion of the three areas. This number of samples was regarded as being a desired minimum for the statistical treatment the object of which was to estimate the final number of samples required.

Because of the indication obtained from the results of the composite sampling, that no differences are to be expected below the first few inches of the soils being compared, sampling was restricted to the first soil depth, the A_1 horizon. Twelve individual samples originally collected for moisture determinations from each burned and unburned portion of the Trenton area were also analyzed.

The results for these study areas are given in Table III.

The data in Table III indicate significant differences* for 3 tests. These are: (1) loss on ignition for the Bartow area, showing a greater quantity of organic matter on the burned portion, and (2 and 3) total nitrogen and hygroscopic moisture for the McNeill area, greater quantities being present in the soil from the unburned portion. In view of the large variation found for each area it was not suprising that these results did not agree with those obtained for the composite samples in which a greater content of organic matter was indicated for the burned portion of the McNeill area, a higher content of organic matter and also nitrogen for the unburned portion of the Bartow area, and a greater content of organic matter on the unburned portion of the Soperton area.

* The test of significance used here is that the difference of the means is at least twice the standard error of the difference.

TABLE III

DETAILED ANALYSES OF SOILS FROM BURNED AND UNBURNED AREAS.

(30 individual samples)

Test	Date of collection	Area	Depth	Unburned area	Burned area	D	+ -	S.E.D.
	1932		Inches	Percent	Percent			
Nitrogen	May 13,	McNeil, Miss.	0-3	.07267	.05852	.01415*	±	.00297
	April 19	Bartow, Fla.	0-3	.04803	.05282	.00497	±	.00268
	May 24	Soperton, Ga.	0-3	.03597	.03698	.00101	±	.00197
	Oct.26,1931	Trenton, Fla.	0-2	.04029	.04642	.00613	±	.00520
Loss on ignition	Ditto	McNeil, Miss.	0-3	4.9368	4.5422	.3946	±	.22212
		Bartow, Fla.	0-3	3.2699	3.7549	.4850*	±	.17555
		Soperton, Ga.	0-3	2.3576	2.2515	.1061	±	.17606
		Trenton, Fla.	0-2	2.3676	2.6908	.3232	±	.30265
Hygroscopic moisture	Ditto	McNeil, Miss.	0-3	1.1896	.9735	.2161*	±	.04896
		Bartow, Fla.	0-3	.9809	.9626	.0183	±	.03897
		Soperton, Ga.	0-3	.4922	.5053	.0131	±	.03515

* Denotes a significant difference

From the estimate of the variability to be expected as shown in Table III, the number of samples necessary to adequately determine the means was worked out for the burned and unburned portions of each area (Table IV). To arrive at this figure it was assumed that the difference between plot means (burned and unburned) should exceed the standard error of the difference by 3 times. The basic formulas and a complete description of the method of analysis are given in the appendix.

Thus far, only one of the areas, the Trenton, has been sampled in the detail indicated in Table IV. For this area it was computed that 72 samples were required in order to obtain reliable results for total nitrogen. A somewhat larger ~~smaller~~ (88) number of samples was indicated for loss on ignition. However, in order to be sure of having sufficient samples, in the event that a greater standard deviation should be obtained than that for the 12 samples, 100 individual samples were collected for analyses. *

In sampling the Trenton area samples were taken at approximately 6 foot intervals in rows and columns. By thus arranging the sampling it was possible to deduct variation due to place correlation and thereby considerably lower the standard error of each mean.

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* It was found that there was very little difference between the standard deviations for the 12 and the 100 samples.

TABLE IV

NUMBER OF SAMPLES REQUIRED TO GIVE SIGNIFICANT *
RESULTS

Area	Test	Samples Required
		Number
Trenton	Nitrogen	72
	Loss on Ignition	88
McNeil	Nitrogen	13
	Loss on Ignition	84
Bartow	Nitrogen	83
	Loss on Ignition	35
Soperton	Nitrogen	1038
	Loss on Ignition	720

* Three standard errors used in computations.

The results for the Trenton area are given in Table V. This table shows conclusively that real differences exist in the chemical composition of the soils compared, there being significantly greater quantities of nitrogen and organic matter in the soil subjected to fire.

One additional point regarding the chemical analyses should be mentioned. No correlation between fire treatment and physical character of the soils as indicated by the five arbitrary soils divisions was found. This is seen from Table VI in which the results of 14 study areas are given.

TABLE V

ANALYSES OF SOILS FROM BURNED AND UNBURNED AREAS

(100 Individual Samples, Aug. 31, 1932)

TRENTON, FLORIDA.

Test	Depth	Unburned mean	Burned mean	D	±	S.E.D.
	Inches					
Total nitrogen		.0392	.0423	.0031	±	.0010
Loss on ignition	0 - 7*	2.2818	2.7191	.4373	±	.0747
Hygroscopic moisture		.5114	.6389	.1275	±	.0246

* Represents A_1- horizon which varied from 3 to 7 inches in depth.

TABLE VI

RELATION OF FIRE TREATMENT TO ARBITRARY SOIL DIVISION.

Area	Arbitrary Soil Division	Greater quantities of nitrogen and organic matter on (1) Burned and (2) Unburned portions.
Choctawhatchee National Forest,	Excessively drained deep sands	Unburned
Bartow, Florida	Ditto	Burned
Trenton, Florida	Well drained sands	Burned
Lake City, Florida	Ditto	Burned
Soperton, Georgia	Ditto	No difference
Chipley, Florida	Moist sands	Unburned
Raiford, Florida	Ditto	Burned
Ridgeland, Georgia	Ditto	Unburned
Cowhouse Island, Ga.	Poorly drained sands	Burned
Suwannee Lake, Ga.	Ditto	Unburned
Starke, Florida	Ditto	Unburned
McNeil, Miss.	Sandy & silt loams	Unburned
Urania, Louisana	Ditto	Burned
Clemson Coast Agr. Exp. Sta., S. C.	Ditto	Unburned

Results of Mechanical Analysis.

The mechanical analyses indicated that, with the exception of the Urania area, all burned and unburned soils compared were closely alike in physical composition. The soil from the burned portion of the Urania area was found to have a higher percentage of fine particles than that from the unburned. These results are given in Table IX, see appendix.

Field Observations

The A_1 horizons of the soils from burned and unburned areas were found to represent two distinctly different physical conditions. These were: (1) for the unburned area, a mellow permeable soil in which insect, animal, and earthworm activity was much in evidence, and (2) for the burned area, a compact impermeable soil showing no evidence of an active macrofauna.

The A_1 horizon of the unburned Trenton soil was found to be significantly deepter than that of the burned soil. The mean values of 100 measurements for each area were: unburned, 4.60 inches and burned, 3.63 inches.

A well defined A_0 horizon was present on all unburned areas. This consisted of a layer of litter from 1 to $2\frac{1}{2}$ inches in depth underlain by a layer of duff, from $\frac{1}{2}$ to 1 inch deep (Plate 1 - A). It is noteworthy that, although areas on which no fires had occurred for 50 to 75 years were examined, the deepest accumulation of litter and duff found was $3\frac{1}{2}$ inches (Plate II). The average depth of litter and duff for all areas was approximately 2 inches. Only a small quantity of litter, the needle fall of the current year, was usually present on the ferquently burned areas.

-A-

Forest floor unburned for 38 years. Note the litter, duff layer, and the top of the A_1 horizon. Area 10, Okefenokee Swamp, Georgia. March, 1931.
#255, 992

-B-

Forest floor burned frequently. Note sparse layer of litter and absence of duff. Escambia Co. Ala. December , 1930.
#256, 495.

PLATE I

-A-

#256, 492 3

-B-

A and B. Details of forest floor unburned for 10 years. Litter and duff $3\frac{1}{2}$ inches deep. Same area as that shown in Plate IV. December, 1930.
#256, 492.

A marked difference was found in the nature of the vegetation on burned and unburned areas. These differences are illustrated by Plates III and IV, and by the plates in the appendix. For the burned areas, an abundant ground cover was present consisting of grasses and a wide variety of herbaceous plants. Two distinct conditions, depending on the density of the timber, were found in the unburned areas. In openings in the forest canopy pure strands of wire grass (Aristida sp.) are found. After several years of protection, this grass forms a rough which may be one foot or more in depth, (Plate V). A slightly compacted layer several inches in thickness of dead and partly decomposed leaves may accumulate. Overlying this material a loose mass is found of green grass interwoven with recently dead leaves and stems. Under dense stands of pine, however, wire grass is smothered out by the accumulation of pine needles (Plate VI) and eventually the forest floor approaches the condition illustrated in PlateI-A.

A greater number of individual herbaceous plants, including grasses, was found per unit of area on the burned soils than on these protected from fire. Probably the most important factors in causing this condition are the removal of the pine litter by fire and the fact that the individual grass plants on the burned areas are smaller than those on the unburned, thereby permitting a greater number per unit of area. Fires remove the dead plant materials, and where one large stool of wire grass is found on an unburned soil, several plants may be present on a similar burned area. This fact is illustrated in Tables VII and VIII. Through an error the asters (Chrysopsis) were included with the grasses in Table VII.

PLATE III

Frequently burned stand of longleaf pine on Orangeburg sandy loam. Conecuh County, Ala. Note abundance of grass and scarcity of pine litter. December, 1930.

#256, 494

PLATE IV.

Stand adjacent to that shown in Plate III but from which fire had been excluded for 15 years. Note the sparse ground cover but abundant litter. Heavy understory of dogwood and southern red oak. December, 1930.

#256, 508.

Dense rough of wire grass as a result of 12-15 years protection from fire. Forest type: Slash pine. Soil: Bladen sandy loam. Vicinity: Crestview, Okaloose County, Fla. November, 1931.
#264, 177.

7-year rough of wire grass and broomstraw. Escambia County, Ala.
December, 1930.
#256, 503.

PLATE V

PLATE VI.

Longleaf pine unburned for 7 years. The pine litter has smothered out practically all herbaceous plants. Escambia County, Alabama.

December, 1930. #256, 498

TABLE VII

TOTAL NUMBER OF GRASSES AND OTHER PLANTS ON BURNED AND UNBURNED AREAS.

CONECUH COUNTY, ALABAMA.

(Based on one milacre plot for each area)

Type of Vegetation	Number of plants		Total	Percent of Total	
	Unburned	Burned		Unburned	Burned
Grasses	228	626	854	27	73
All others	75	136	211	36	64
Total	303	762	1065	28	72

TABLE VIII

TOTAL NUMBER OF GRASSES, ASTERS, AND ALL OTHER PLANTS ON BURNED AND UNBURNED AREAS.

BALDWIN COUNTY, ALABAMA.

(Based on one milacre plot for each area)

Type of Vegetation	Number of Plants		Total	Percent of Total	
	Unburned	Burned		Unburned	Burned
Grasses	495	701	1196	41	59
Chrysopsis	38	184	222	17	83
All others	18	65	83	22	78
Total	551	950	1501	37	63

Further observations revealed that leguminous plants were much more abundant on frequently burned areas, although no data supporting this statement are presented in this report. While on a field trip in the vicinity of Thomasville, Georgia, with H. L. Stoddard*,

* Formerly of the U. S. Biological Survey and now in charge of the Cooperative Quail Investigations. Thomasville, Georgia.

the prevalence of legumes on burned areas was pointed out by this investigator. Mr. Stoddard stated that the natural germination of the seeds of some of the indigenous leguminous plants may be increased from 10 to 15 percent to as high as 90 percent by subjecting them to heat. He attributes the abundance of leguminous plants on frequently burned areas to this characteristic and to the opening of the stand of ground cover by the fire thereby giving these plants a chance for establishment.

A statement of the occurrence of hardwoods on burned and unburned areas should be qualified. Generally speaking fires reduce the number of hardwoods present. In the poorly drained flatwoods where the species found do not sprout readily after fire, this is always true. Such species are: laurel oak (Quercus laurifolia), water oak (Q. nigra), sweet bay (Magnolia virginiana), red bay(Persea palustris), red maple (Acer rubrum), and high bush huckleberry (Vaccinium arboreum),. Gallberry (Ilex glabra) and wax myrtle (Myrica cerifera) are always present on such sites. The last two named plants are also found on burned sites as they sprout vigorously after fire.

On the better soils found in the upper Coastal Plain (X) in the states between South Carolina and Louisiana, white hickory (_Carya alba_) red gum (_Liquidambar styraciflua_), southern red oak (_Q. rubra_), and flowering dogwood (_Cornus florida_)are found associated with longleaf pine. Because of frequent fires these trees are rarely large. They persist, however, on frequently burned areas and under protection they may form a dense almost impenetrable undergrowth with the accompanying growth of woody vines such as wild grape (_Vitis sp._), poison ivy (_Rhus triloba_), virginia creeper (_Psedera quinquifolia_), and yellow jessamine (_Gelsemium sempervirens_). For photographs of the vegetation on burned and unburned areas see appendix.

On deep sandy soils such as the extensive sands of western and central Florida, firee do not reduce the number of hardwoods present. The two most common species are turkey oak (_Q. catesbaei_)and bluejack oak (_Q. cinerea_). These trees sprout prolifically after a fire and the destruction of a single stem normally results in the formation of a clump varying in number from a few to fifteen or twenty stems.

DISCUSSION

The inconsistency which so far characterizes the results of the tests for nitrogen and organic matter makes it impossible at this stage of the study to draw definite conclusions regarding the relative quantities of these materials in soils from burned and unburned areas. The results for the Trenton area sampled in detail are conclusive. Beyond doubt, real differences in nitrogen and organic matter were indicated. Real differences were also found in organic matter for the Bartow area, and in total nitrogen and hygroscopic moisture for the McNeil area. However, as two of these areas indicated one trend, whereas the third indicated an opposite trend, the question immediately arises whether these differences are to be attributed to fire treatment or inherent differences which have always existed in the soils. The need for further study is definitely indicated. There appears to be no doubt that soils subjected to frequent fires have a higher percentage of replaceable calcium than soils protected from fire. Likewise, such soils are less acid, a condition to be attributed to the higher calcium content. These results are in accordance with those of Alway and Rost (1) working in the Lake States. These investigators found no differences in the chemical properties of burned and long unburned soils supporting jack pine after one severe forest fire other than differences in calcium and acidity. The odds showing more magnesium (Table II) for the third

soil depth of the unburned areas are hardly of importance and are probably due to chance. It is unlikely that fire should affect the third soil depth and not the first.

The lack of correlation between effect of fire and physical characteristics of the soil is noteworthy. Of the five arbitrary soil divisions into which all the soils studied were classed none showed more or less effect of fire than the others.

The fact that no striking differences were revealed by the composite sampling indicates clearly that no great quantitative differences exist between the chemical composition of burned and unburned soils. However, the claim is not made that even very small sifferences may not be of considerable importance from a physiological viewpoint. The influence of the presence of minute quantities of nutrients in plant nutrition is well known, and further study may reveal that the quantitatively small differences, particularly in calcium, found in burned and unburned soils may noticeably affect tree growth.

The magnitude of the differences in the burned and unburned soils is somewhat better visualized by converting the differences in the quantity of plant nutrients to a pounds per acre basis. Assuming a weight of 4,000,000 pounds for an acre foot of soil, then a difference of 0.001 percent means a difference of 10 pounds per acre for the 0 - 3 inch depth. Thus in Table IX (appendix) the maximum difference in total nitrogen for the burned and unburned soils was 0.041 percent, area 9. This amounts to a difference of 410 pounds of nitrogen per acre for the first 3 inches of soil. If many of the differences were of this

magnitude more importance would be attached to the results. However, the average difference for all areas is but 0.015 percent based on the extensive sampling. The results of the intensive sampling method are even more conservative. The maximum difference in nitrogen content between burned and unburned soils, and the only difference which was significant, was 0.014 percent, area 13. The mean of the differences for the three remaining areas sampled in detail was 0.003 percent or only 30 pounds per acre to a 3 inch depth. It should be distinctly understood that these figures are for <u>total</u> nitrogen and not nitrogen in a form usable by plants. The percentage of this total nitrogen which is soluble, commonly referred to as available nitrogen, is not known, but it is doubtless rather small. For this reason no intelligent means are at hand for estimating the quantity of commercial fertilizer equivalent to the figures for total nitrogen given for the forest soils discussed here. Such comparisons are misleading, and too inaccurate to be of use here.

A condition which, following further investigation, may possibly prove to be of importance is the depth of the A_1 horizons of soils on the burned and unburned areas. As mentioned already the soil from the burned Trenton area was found to have greater quantities of nitrogen and organic matter than the unburned soil by amounts which were statistically significant. However, A_1 horizon of the unburned soil was 0.97 inches deeper than that of the burned soil. The total quantity of nitrogen per acre for the A_1 horizon for each soil may be computed as follows: Burned area A_1 horizon, 3.63 inches deep with a

nitrogen content of 0.0423 percent equals 512 pounds per acre; unburned area, A_1 horizon 4.60 inches deep with a nitrogen content of 0.0392 percent equals 601 pounds per acre. These figures are meaningless, however, if used in their present form. There is no reason to believe that pine roots derive all their nutriment from the A_1 horizon. A comparison, therefore, of the absolute quantity of nitrogen in the first 4.6 inches of the unburned soil and the first 3.63 inches of the burned soil is unfair. This gives a soil depth of 0.97 inch more for the unburned soil. That the soil depth 3.63 to 4.60 inches for the unburned area contains a greater quantity of nitrogen than the same depth of soil on the burned area there can be no doubt, because this depth is the lower part of the A_1 horizon in the unburned and the upper part of the A_2 horizon in the burned soil. The abrupt change from a relatively high to a lower content of organic matter and therefore, nitrogen from the A_1 to the A_2 horizon is attested by the much darker color of the A_1. However, the upper portion of the A_2 horizon does have a certain quantity of nitrogen and this amount should be considered in the above comparison of the absolute quantities computed on an acre basis. This quantity may be roughly approximated as follows: The total nitrogen percentages for the 0-2 inch and also the 6-8 inch soil depths for the Trenton area are 0.0464 and 0.0227. The average is 0.0345 percent. This figure should approximate the percent nitrogen for the 3.63 to 4.60 inch soil depth of the burned area. If, now, this figure be applied to 0.97 inch, the depth of the above soil horizon, a total quantity of nitrogen is obtained amounting to 112 pounds per acre.

It is now possible to make a more just comparison of the absolute quantities of nitrogen in the burned and unburned soils. Comparing the 4.60 soil depth for both areas, we fine 601 pounds of nitrogen for the unburned area and 512 plus 112 pounds, or a total of 624 pounds for the burned area, a difference of 3.7 percent. This difference should be compared with the percentage difference of 7.3 percent obtained for the total niteogen values in Table V. Likewise, a difference of 4.1 percent is obtained for the actual field difference in organic matter as compared with a difference of 16.2 percent based on the loss on ignition values in Table V.

This method of analysis suggests at once the advisability of basing all future soil sampling not on a collection made according to strict horizons only, but based also on an effective soil depth to be determined from studies of the root systems of longleaf and slash pines.

One of the difficulties of the present study is the impossibility of being certain that the soils compared were actually the same prior to variations in their fire history. In other words, is the slight difference in the chemical composition of the soils of the burned and unburned areas to be attributed to fire or to inherent variations within the soil which existed before variations in treatment by fire? Obviously the first step to be taken to remedy this difficulty is to compare only soils lying adjacent to each other. Variations within the soil are thus minimized as far as possible. As pointed out, this precaution was taken wherever it was possible to do so. It was

further believed that an idea of the original composition of the soils might be obtained by comparing the analyses of samples from the greater depths. For this reason the third soil depth was collected in the extensive sampling. It was believed that, if the assumption be made that frequent fires do cause changes in the chemical composition of the soil, any changes caused by fire would not be noticeable at the greater soil depths. In support of this belief the lack of correlation is pointed out between fire treatment and replaceable calcium content, and also pH value for the second and third soil depths (Table II). It appears, therefore, that the assumption is justified that the effect of fire is not noticeable below the first few inches from the soil surface. However, it should be pointed out that the attempt to use the third soil depth failed as a criterion of the comparability of the burned and unburned soils. Large variations within any one soil were found, and the method of sampling was inadequate to eliminate these variations. Because of the expense it was not possible to analyze more than one horizon for the soils which were sampled intensively.

A point worthy of comment is the apparent contradiction of a fact well recognized by soil scientists throughout the world. This is the superiority of grass over tree vegetation in increasing and maintaining soil organic matter. It has been pointed out that frequently burned areas in the longleaf pine region are essentially grassland, whereas, the areas long protected from fire are characterized by little or no herbaceous vegetation. However, no marked difference in the content of nitrogen and organic matter was found in these two classes

of soil during the present study. Jenny (2) has shown that there are large differences in the nitrogen and organic matter content of grassland and forest soils throughout the eastern United States. This work included portions of each of the several states covered by the present study. This investigator shows differences of approximately 0.050 percent between prairie and forest soils in Mississippi. The discrepancy between the present work and Jenny's may be explained by pointing out that fire histories of the areas reported here have not differed for any great length of time, probably 20 years as an average. The sites of burned and unburned areas were originally the same. Whether these forest areas were subjected to frequent or infrequent fires, a matter of controversy among ecologists, is of no consequence. The important point is that, from the viewpoint of fire history, the soils were identical; and the period, varying from 10 to 50 years, during which the soils have received different treatments has not been long enough for major differences to develop in the amounts of organic matter. Vast areas of land, once covered with longleaf pine forests, are now essentially grassland, pine reproduction being kept off by ? c hogs annual fires (Plates VII and VIII). Whether the fertility of the soils of such areas will increase in the future is a matter to be determined. The present work indicates that no major changes in organic content will occur for at least 25 years or longer.

One additional point should be discussed regarding the content of organic matter in pine forest soils of the South. Doubt has been expressed by certain soil investigators that the quantity of

PLATE VII

Grassland originally covered with longleaf pine. This area burns annually and the pine reproduction is unable to become established. Note longleaf pine seedlings malformed as a result of fire.

Vicinity, Starke, Bradford Co., Fla.
(See also Plate VII)
#264, 209

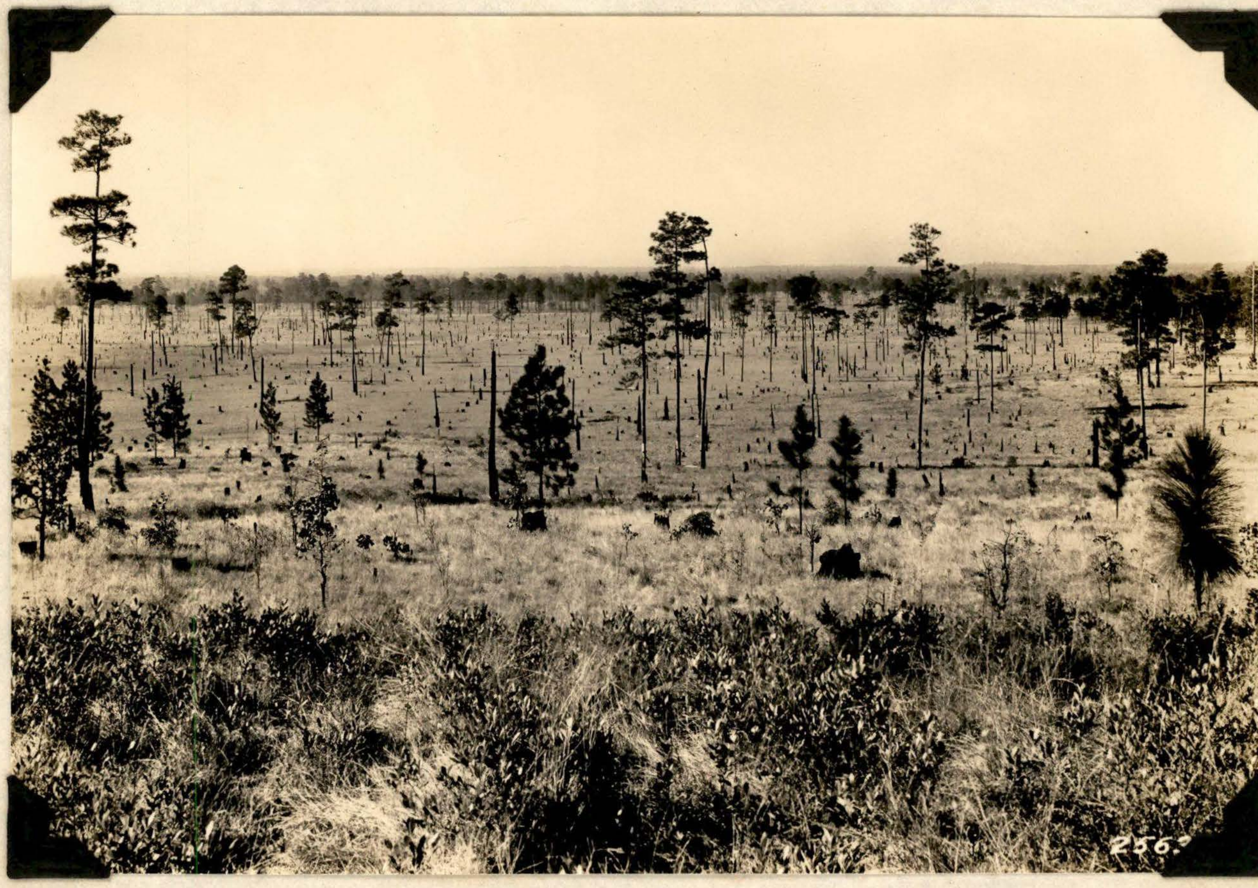


Plate VIII

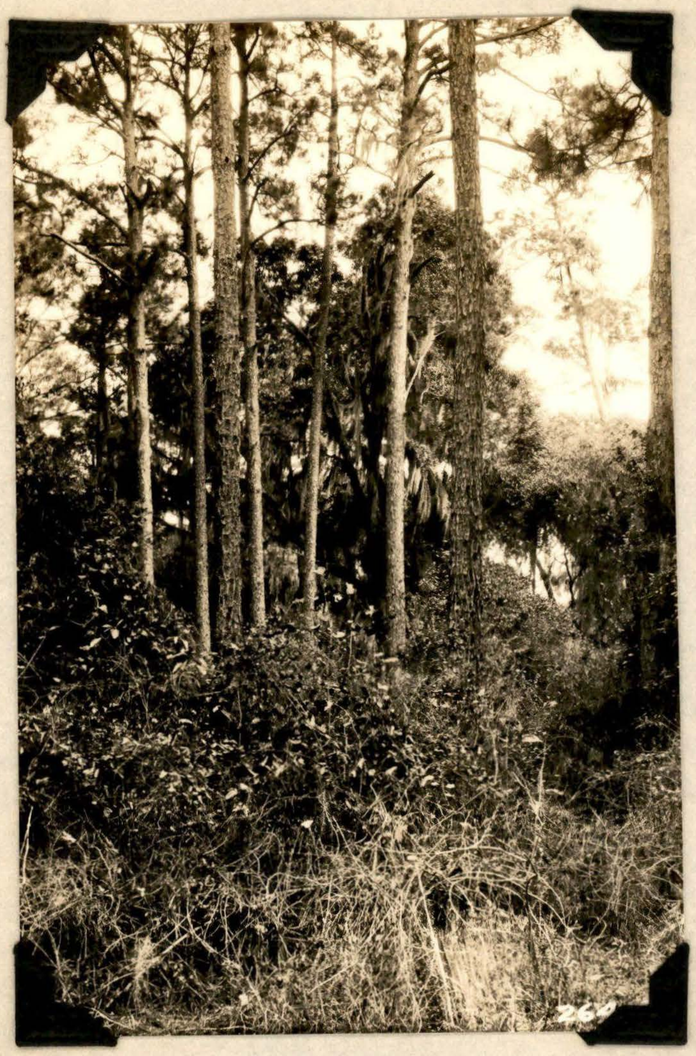
Cut-over longleaf pine land burned annually. Such land has little chance of restocking with pine unless protected from fire. In this region hogs also do much damage to longleaf reproduction.

Greene Co., Miss.

#256, 377.

of organic matter which the soil derives through the decomposition of pine litter is sufficient to be of importance in soil fertility. The analyses of the soil from area 8 do not justify this doubt. The soils of groups II and III (Figure I) are comparable from the standpoint of drainage and texture. The relatively high percentage of nitrogen and organic matter of the soil from Cumberland Island when compared to the other soils of groups II and III, area 8, is apparent from the histograms. This area has been unburned for 40 years and probably longer. Because of the heavy stand of timber no ground cover exists and the only source of organic matter is from the pines and scattered hardwoods forming an understory (Plate IX). The results of this area make it appear that, following a period of protection from fire, probably 50 years or longer, the soil growing a stand of pine may be materially enriched from the natural accumulation of organic matter from the forest trees. This point is of theoretical importance rather than practical because of the time required for the condition to become established.

In conclusion, mention should be made of the various changes in the sampling technique used in this study. Before the field work was undertaken, the fact was recognized that the analysis of composites of four individual samples would not permit an accurate comparison to be made of any particular soils from comparable burned and unburned areas. It was believe, however, that if a number of such areas were sampled, any major differences in the chemical analyses would be indicated for the soils subjected to different fire treatment. The results of the composite analyses revealed that only differences in



#264, 198

#264, 204

PLATE IX

Area unburned for at least 40 years. Heavy stand of longleaf pine results in no ground cover. Litter and duff 2 inches deep.
Area 8. Cumberland Island, Ga.

replaceable calcium and hydrogen ion concentration could be detected by this method. It follows, then, that two conditions may exist, either separately or simultaneously. First, differences in calcium and acidity may be the only real differences between the soils. Second, other real differences exist but are too minute to be detected by a relatively crude method of sampling. In view of the results of the intensive sampling it seems likely that differences in nitrogen and organic matter are indeed small and the inconsistency of the results suggests that fire treatment may not be associated with even these small sifferences. Determination of the physiological importance of these small differences is the object of a special study now under way.

SUMMARY

1. Chemical analyses were made of pine forest soils in the South subjected to frequent fires and comparable soils protected for at least 10 years.

2. Tests for total nitrogen, total carbon, loss on ignition, hygroscopic moisture, and replaceable magnesium failed to reveal any consistent or striking differences in these soils.

3. Soils on burned areas were, in general, found to have a greater percentage of replaceable calcium to a depth of 2 to 3 inches, than the soils subjected to fire. Likewise, these soils had consistently greater pH values (less acid) than the soils on the unburned areas.

4. Evidence was found which indicates that there may be a considerable accumulation of organic matter in pine forest soils. This material is largely formed from the decay of pine needles which may accumulate to a depth of 3 to 3½ inches in closed stands following complete protection from fire.

5. The A_1 horizons of soils on unburned areas were mellow, loose and permeable and the location of much insect and animal activity; whereas, the A_1 horizons of soils on burned areas were compact and impermeable and were not characterized by abundant insect and animal activity.

6. A greater number per unit area and a wider variety of herbaceous plants were found on burned areas than on unburned.

7. Throughout most of the region studied, fire was found to decrease the number and variety of woody plants including tree species.

On excessively drained soils characterized by a xerophytic type of vegetation no decrease in the number of woody plants was observed on burned areas. This is attributed to the ability of the hardwoods common on such sites (*Q. catesbaei* and *Q. cinerea*) to produce sprouts following fire.

LITERATURE.

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APPENDIX

TABLE IX

COMPLETE SUMMARY OF CHEMICAL ANALYSES

Each figure is the mean of duplicate determinations.

Area No.	Location and date of collection	Soil	Sample	Hyg. water * %	L.I. ** %	C %	N %	CaO %	MgO %	pH	Sand 2.00 - 0.05 mm %	Silt & clay 0.05-0.00 mm %
I	Choctawhatchee Natl. Forest April 12, 1931, Composite of 4 samples	Norfolk fine sand Unburned	Soil: 0 - 2"	0.426	2.518	1.336	0.042	0.028	0.018	5.00		
			6"-10"	0.281	1.110	0.505	0.020	0.022	0.016	5.25		
			28"-30"	0.205	0.681	0.222	0.011	0.023	0.016	5.45		
		Burned	0 - 2"	0.292	1.905	1.063	0.031	0.028	0.019	5.12		
			6"-10"	0.189	0.934	0.373	0.016	0.023	0.016	5.20		
			28"-30"	0.173	0.626	0.168	0.011	0.023	0.016	5.25		
II	Bartow, Florida March 23, 1931 Composite of 4 samples.	Ft. Meade fine sand Unburned	Soil: 0-3"	1.070	4.218	2.001	0.061	0.090	0.026	5.17		
			10"-12"	0.612	2.132	0.800	0.022	0.046	0.020	5.67		
			24"-28"	0.494	1.748	0.573	0.018	0.034	0.018	5.71		
		Burned	0-3"	0.854	3.600	1.694	0.046	0;083	0.026	5.67		
			10"-12"	0.702	2.244	0.876	0.018	0.049	0.018	5.71		
			24"-28"	0.552	1.521	0.498	0.013	0.039	0.017	5.75		
	April 20, 1932 Mean of 30 individual samples	Unburned		0.981	3.270		0.048					
		Burned		0.963	3.755		0.053					

* Hygroscopic water
** Loss on ignition.

TABLE I — Continued

Area No.	Location and date of collection	Soil	Sample	Hyg. water	L. I.	C	N	CaO	MgO	pH	Sand: 2.00 - 0.05 mm	Silt & clay 0.05 0.00 mm
				%	%	%	%	%	%		%	%
	Trenton, Fla. Oct. 26, 1931	Blanton fine sand Unburned closed stand no grass	Litter & Duff. mean of 6 sampls	3.905	9.078	47.017	0.552					
			Soil: 0-2"	0.484	2.249	1.305	0.033	0.034	0.016	5.29	91.8	8.2
			6"-9"	0.311	1.152	0.486	0.018	0.016	0.011	5.54	92.0	8.0
			16"-18"	0.228	0.815	0.456	0.011	0.012	0.008	5.58	91.9	8.1
		Unburned cl. stand no grass	0-2"	0.304	1.840	1.095	0.032	0.033	0.015	5.45	92.5	7.5
			6"-9"	0.255	0.939	0.430	0.018	0.024	0.010	5.88	93.2	6.8
			16"-18"	0.191	0.693	0.288	0.012	0.016	0.008	5.92	93.3	6.7
III	Composite of 4 samples	Unburned opening in stand	0-2"	0.404	2.165	1.230	0.032	0.028	0.013	5.29	92.9	7.1
			6"-9"	0.249	1.196	0.474	0.018	0.015	0.013	5.71	92.0	8.0
			16"-18"	0.196	0.884	0.282	0.013	0.011	0.010	5.84	92.3	7.7
		Burned	0-2"	0.569	2.925	1.665	0.040	0.066	0.018	5.97	92.7	7.3
			6"-9"	0.406	1.346	0.534	0.020	0.014	0.008	5.67	92.8	7.2
			16"-18"	0.228	0.990	0.336	0.012	0.011	0.005	5,75	92.7	7.3
		Burned	0-2"	0.441	2.266	1.335	0.036	0.044	0.011	5.71	91.3	8.7
			6"-9"	0.215	0.948	0.420	0.018	0.020	0.008	5,71	91.9	8.1
			16"-18"	0.203	0.673	0.288	0.014	0.015	0.009	5.84	92.3	7.7
	Oct. 26, 1931 Mean of 12 ind. samples	Unburned closed stand	0-2"	0.372	2.368	1.411	0.040			5.19		
			6"-9"	0.263	1.300	0.644	0.024			5.62		
			16"-18	0.194	0.879	0.373	0.017			5.55		
		Burned	0-2"	0.433	2.691	1.626	0.046			5.82		
			6"-9"	0.250	1.297	0.634	0.023			5.52		
			16"-18"	0.183	0.837	0.370	0.016			5.52		
		Unburned closed stand		0.511	2.282		0.039					
	Aug. 30, 1932 mean of 100 ind. samples	Burned		0.639	2.719		0.042					

Area No.	Location and date of Collection	Soil	Sample	Hyg. water	L. I.	C	N	CaO	MgO	pH	Sand: 2.00 - 0.05 mm	Silt & clay 0.05-0.00 mm
				%	%	%	%	%	%		%	%
IV	Lake City, Fla. December 17,1931 Composite of 4 samples	Blanton fine sand Unburned	Soil: 0-2"	0.195	1.682	1.005	0.035	0.021	0.007	5.37	92.5	7.5
			5"-8"	0.194	0.766	0.372	0.015	0.011	0.006	5.92	93.6	6.4
			18"-20"	0.120	0.470	0.240	0.010	0.007	0.005	6.00	93.7	6.3
		Burned	0-2"	0.387	2.115	1.425	0.035	0.021	0.009	5.46	92.6	7.4
			5"-8"	0.222	1.042	0.540	0.016	0.007	0.004	5.62	93.1	6.9
			18"-20"	0.160	0.709	0.360	0.011	0.005	0.003	5.62	91.8	8.2
V	Soperton, Ga Feb. 12, 1931 Composite of 4 samples	Ruston sand Unburned	Soil: 0-3"	0.522	2.060	1.749	0.033	0.059	0.027	5.25		
			6"-10"	0.256	0.914	0.457	0.011	0.030	0.020	5.58		
			14"-20"	0.120	0.570	0.240	0.005	0.023	0.022	6.01		
		Burned	0-3"	0.375	2.171	1.280	0.034	0.038	0.029	5.75		
			6"-10"	0.162	0.806	0.349	0.010	0.026	0.023	5.79		
			14"-20"	0.170	0.651	0.186	0.003	0.024	0.024	5.71		
	May 24, 1932 Mean of 30 samples	Unburned	0-3"	0.492	2.358		0.036					
		Burned	0-3"	0.505	2.252		0.037					
VI	Chipley, Fla. Composite of 4 samples Nov. 9, 1931	Norfolk fine sand Unburned	Soil 0-2"	0.544	2.583	1.485	0.034	0.029	0.011	5.54	89.9	10.1
			7"-10"	0.270	1.238	0.540	0.022	0.014	0.005	5.71	90.7	9.3
			14"-17"	0.191	0.871	0.330	0.012	0.012	0.007	5.84	89.8	10.2
			0-2"	0.424	2.453	1.455	0.041	0.022	0.010	5.41	88.8	11.2
			10"-12"	0.191	1.204	0.468	0.019	0.011	0.007	5.75	88.7	11.3
			16"-20"	0.149	0.967	0.258	0.012	0.013	0.006	5.97	88.5	11.5
		Burned	0-2"	0.312	2.153	1.170	0.032	0.029	0.010	5.92	88.4	11.6
			7"-10"	0.250	1.263	0.462	0.021	0.015	0.006	5.84	89.2	10.8
			14"-17"	0.174	1.055	0.282	0.012	0.013	0.008	5.87	87.9	12.1

TABLE I— Continued

Area No.	Location & date of Collection	Soil	Sample	Hyg. water	L. I.	C	N	CaO	MgO	pH	Sand: 2.00 - 0.05 mm	Silt & clay 0.05 - 0.00 mm
	Raiford, Fla.	Blanton	Soil:	%	%	%	%	%	%		%	%
		fine	0-2"	0.294	1.854	1.185	0.034	0.018	0.008	5.37	88.9	11.1
	Composite of	sand	4"-8"	0.221	0.995	0.462	0.017	-	-	5.29	-	-
	4 samples	Unburned	18"-20"	0.148	0.634	0.270	0.012	0.004	0.005	5.33	89.5	10.5
VII	Dec. 15, 1931.	Burned	0-2"	0.322	2.056	1.215	0.039	0.020	0.009	5.33	90.1	9.9
			4"-8"	0.192	0.853	0.378	0.017	0.007	0.005	5.46	-	-
			18"-20"	0.141	0.613	0.264	0.010	0.005	0.003	5.46	89.7	10.3
	Cumberland		Litter	3.854	94.727	49.721	0.630	-				
	Island, Ga.	Norfolk	Duff	2.750	57.417	34.100	0.639	-				
	Composite of	fine	Soil:									
VIII	4 samples	sand	0-2"	0.810	5.087	2.925	0.083	0.024	0.010	4.23	93.1	6.9
	Dec. 4, 1931		5"-8"	0.497	2.080	1.056	0.026	0.017	0.009	5.25	94.6	5.4
			16"-18"	0.353	1.326	0.630	0.017	0.007	0.005	5.33	94.6	5.4
	Ridgeland, S. C.	Norfolk	Soil:									
	Composite of	fine	0-3"	1.469	9.449	5.755	0.169	0.130	0.048	4.70		
	4 samples	sand	5"-9"	0.370	1.950	0.723	0.034	0.040	0.026	5.17		
		Unburned	12"-18"	0.177	0.886	0.234	0.013	0.023	0.023	5.00		
IX	Feb. 4, 1931	Burned	0-3"	0.959	7.263	4.362	0.128	0.173	0.055	5.58		
			5"-9"	0.289	1.946	0.794	0.027	0.023	0.032	5.67		
			12"-18"	0.099	0.748	0.305	0.008	0.018	0.019	5.67		
	Racepond, Ga.	Leon	Litter	1.862	98.25	51.51	0.467	-	-	-		
	Composite of	fine	Duff	2.257	59.74	35.91	0.561	0.237	0.135	3.64		
	4 samples	sand	Soil:									
		Unburned	0-3"	0.259	2.525	1.624	0.033	0.031	0.025	4.15		
			6"-9"	0.038	0.369	0.240	0.007	0.023	0.018	5.17		
X	Feb. 20, 1931		11"-14"	0.898	2.983	1.635	0.055	0.025	0.027	5.00		
			Litter	2.674	95.45	52.09	0.385	-	-	-		
		Burned	Soil:									
			0-3"	0.536	3.515	2.277	0.057	0.043	0.027	4.40		
			6"-9"	0.086	0.497	0.366	0.015	0.026	0.018	5.04		
			11"-14"	0.192	4.695	2.201	0.058	0.029	0.017	4.99		

TABLE IX, Continued

Area No.	Location & date of Collection	Soil	Sample	Hyg. water %	L. I. %	C %	N %	CaO %	MgO %	pH	Sand: 2.00 - 0.05 mm %	Silt & clay 0.0 -0.00mm %
	Waycross, Ga.	Leon	Litter	2.125	97.30	52.57	0.475	-	-	-		
		fine	Duff	1.846	60.51	33.62	0.645	0.158	0.148	3.39		
	Composite of	sand	Soil:-									
	4 samples	Unburned	0-3	1.056	7.502	4.487	0.109	0.036	0.040	3.72		
XI			6"-10"	0.061	0.233	0.168	0.008	0.022	0.017	5.33		
	Feb. 23, 1931		10"-14"	0.548	2.237	1.252	0.038	0.023	0.021	4.95		
		Burned	0-3	0.722	5.447	3.324	0.093	0.044	0.033	3.90		
			6"-10"	0.064	0.450	0.282	0.014	0.023	0.014	5.33		
			10"-14"	1.032	4.842	2.546	0.065	0.022	0.023	4.53		
	Starke, Florida	Portsmouth	Soil:-									
		fine	0-3"	0.903	6.419		0.118					
	Composite of	sand	5"-9"	0.047	0.495		0.016					
	4 samples	Unburned	12"-16"	0.023	0.196		0.009					
XII	Jan. 21, 1931	Burned	0-3"	0.457	3.541		0.079					
			5"-9"	0.046	0.440		0.017					
			12"-16"	0.023	0.170		0.010					
			18"-22"	0.033	0.250		0.011					
	McNeil, Miss.	Orange-	Soil:-									
		burg	0-2"	0.814	4.147	2.100	0.061	0.049	0.024	5.50	61.7	38.3
	Composite of	fine sandy	6"-9"	0.680	2.489	0.672	0.030	0.023	0.019	5.50	60.4	39.6
	4 samples	loam	10"-14"	0.938	2.802	0.396	0.024	0.022	0.025	5.21	54.3	45.7
	Nov. 5, 1931	Unburned										
			0-2"	0.889	4.516	2.265	0.062	0.059	0.022	5.50	65.4	34.6
XIII	Mean of 30 ind,	Burned	6"-9"	0.804	2.777	0.672	0.031	0.029	0.019	5.45	56.5	43.5
	samples.		10"-14"	1.057	3.012	0.370	0.025	0.029	0.021	5.37	54.0	46.0
	May 5, 1932	Unburned	0-3"	1.190	4.937		0.073					
		Burned	0-3"	0.974	4.542		0.058					

TABLE IX - Continued

Area No.	Location & date of collection	Soil	Sample	Hyg. water	L. I.	C	N	CaO	MgO	pH	Sand: 2.00 - 0.05 mm	Silt & clay 0.05 - 0.00 mm
				%	%	%	%	%	%		%	%
		Caddo( )	Soil:									
	Urania, La.	silt	0-2"	1.009	4.807	2.565	0.074	0.088	0.022	5.45	36.2	63.8
		loam	8"-11"	0.712	2.283	0.858	0.034	0.042	0.017	5.54	36.1	63.9
XIV	Composite of 4 samples	Unburned	11"-14"	1.542	3.047	0.396	0.030	0.054	0.030	5.21	28.5	71.5
		Burned	0-2"	1.207	5.223	2.610	0.086	0.117	0.032	5.97	28.7	71.3
	Nov. 3, 1931.		8"-11"	0.772	2.476	0.798	0.035	0.042	0.025	5.92	28.7	71.3
			11"-14"	1.260	2.729	0.354	0.029	0.035	0.025	5.25	25.7	74.3
	Summerville, S.C.	Norfolk	Litter	2.776	97.49	51.07	0.360	-	-	-		
		fine	Duff	2.348	55.46	31.64	0.530	0.401	0.141	4.06		
	Composite of	sandy	Soil 0-3'	1.768	8.358	4.734	0.137	0.030	0.141	4.23		
	4 samples	loam	6"-10"	0.876	3.116	0.950	0.037	0.017	0.026	4.57		
		Unburned	12"-16"	0.929	3.161	0.406	0.021	0.019	0.021	4.49		
	Feb. 6, 1931.											
XV		Burned	Litter	4.285	93.34	50.31	0.358	-	-	-		
			Soil -		[illegible]							
			0-3"	0.880	6.317	3.662	0.101	0.037	0.027	4.66		
			6"-10"	0.430	2.463	0.651	0.024	0.020	0.021	4.74		
			12"-16"	0.957	2.430	0.326	0.020	0.020	0.021	4.66		

TABLE X

SUMMARY OF ALL STUDY AREAS (GIVEN BY INDIVIDUAL NUMBER) BASED ON 4 SAMPLE COMPOSITES

Chemical Analysis	Soil Depth	Greater on Unburned	Greater on burned	No difference
		Area by individual No.	Area by individual No.	Area by individual No.
Total Nitrogen	1st	1, 2, 9, 15	3, 7, 10, 14	4,5,6,11,13
	2nd	9, 15	10,11,13,14	1,2,3,4,5,6,7
	3rd	2, 7, 9	11,	1, [illegible],3,4,5,6, 10,13,14,15.
Total Carbon	1st	1,2,5,6,9, 11, 15	3, 4, 10, 14	7, 13
	2nd	1,5,6,7,14,15	2,3,4,9,10,11	13
	3rd	1,2,3,5,6,7, 14, 15	4, 9, 10, 11	13
Loss on Ignition	1st	1,2,5,6,9,11, 15	3,4,7,10,13,14	
	2nd	1, 5, 7, 15	2,3,4,10,11, 13, 14	6, 9,
	3rd	2,7,9,14,15	3,4,5,6,10,11,13	1,
Hygroscopic Moisture	1st	1,2,5,6,9,11, 15,	3,4,10,13,14	7,
	2nd	1,5,7,9,15	4, 10	2,3,6,11,13,14
	3rd	9, 14	4, 5, 10, 11	1,2,3,6,7,13,15
Replaceable Calcium	1st	2, 5,	3,7,9,10,11,13, 14,15	1, 4, 6
	2nd	4, 5, 9,	13, 15	1,2,3,6,10,11,14
	3rd	4, 9, 14	2, 7, 10, 13	1,3,5,6,11,15
Replaceable magnesium	1st	11,	14,	1,2,3,4,5,6,7,9, 10,13,15
	2nd	3, 11	5, 14	1,2,4,6,9,10,13, 15.
	3rd	3,7,10,13,14,15	5,	1,2,4,6,9,11
pH Values	1st		1,2,3,5,6,9,10, 11,14,15,	4, 7, 13
	2nd	4, 10, 13	3,5,6,7,9,14,15	1, 2, 11,
	3rd	1, 4, 5, 11	3,6,7,9,13,15,	2, 10, 14

Method of Estimating the Minimum Number of Soil Samples for Analysis in order for Results to be Statistically Significant.

Before computing the number of samples required to afford a reliable estimate of any given soil condition, some idea of the variability of the soil must be obtained. This is done by computing the standard deviation of a small number of samples and assuming this measure to be indicative of the variation which may be expected for a series of a greater number of samples. The following method is then used in calculating the minumum number of samples required:

Formulas used:

(1) $\sigma M_1 = \frac{\sigma_1}{\sqrt{N_1 - 1}}$; $\sigma M_2 = \frac{\sigma_2}{\sqrt{N_2 - 1}}$

(2) $\sigma D = \sqrt{(\sigma M_1)^2 + (\sigma M_2)^2}$

(3) $\frac{M_1 - M_2}{\sigma D} = \alpha$

In which M = mean of samples; the subscript "1" and all other subscripts refer to a universe (Sample plot in this case).

σM_1 = Standard error of the mean.

σ = Standard deviation of the samples from a plot, (i.e. burned or unburned)

N = Number of samples per plot

σD = Standard error of the difference between paired plot means, which is the geometric mean of the standard errors of the means; equals $\sqrt{(\sigma M_1)^2 + (\sigma M_2)^2}$

α = Reliability of difference in terms of size in regard to the standard error of the difference.

The computations for nitrogen values from the Trenton area will illustrate the method:

Burned plot	M_1	=	.046417
	$\sigma 1$	=	.015448
Unburned plot	M_2	=	.040292
	$\sigma 2$	=	.00765

$M_1 - M_2 = .006125$

If we desire the difference to equal or exceed the standard error of the difference by 3: that is, $\frac{M_1 - M_2}{\sigma D} = 3$ or $\frac{M_1 - M_2}{3} = \sigma D$

substituting

$$\frac{.006125}{3} = .0020417 = \sigma D = \sqrt{2(\sigma M)^2}$$

$$2\sigma M^2 = .0000041685$$

$$\sigma M^2 = .0000020843$$

σM = ..0014436 which is the standard error of the mean required.

The number of samples needed is obtained from:

$$\sigma M = \frac{\bar{\sigma}}{\sqrt{N-1}} \quad \text{where } \bar{\sigma} = \sqrt{\frac{N_1(\sigma 1)^2 + N_2(\sigma 2)^2}{N_1 + N_2}} = .012189$$

$$\sqrt{N-1} = \frac{\bar{\sigma}}{\sigma M} = \frac{.012189}{.0014436} = 8.44$$

N = 72, the necessary number of samples from each plot.

ANALYTICAL METHODS

Preparation for Soil Analysis.

Upon receipt of the samples of the different soil horizons as collected in the field, they were spread out immediately upon wrapping paper in the laboratory to air dry. The air-dried samples were placed on a 2 mm. seive and all materials which would pass through the sieve was forced through by shaking and gentle rubbing. The residue remaining on the sieve was undecomposed organic matter such as roots, etc., large lumps of charcoal, small stones and coarse sand. This residue made up a very small proportion of the soil (insufficient material for analysis) and was discarded. The soil material passing through the 2 mm. seive was placed in a suitable container for storage. The seived samples were given laboratory numbers and a description of them together with the field notes collected on them was placed opposite the numbers in the laboratory ledger. Subsequent to this treatment and registration the samples lost their identity except for their laboratory numbers, until after the chemical analysis and other observations had been made.

The determinations of the hygroscopic moisture, the loss on ignition, the total nitrogen and the total carbon were made on finely ground subsamples. The subsamples were taken after thoroughly mixing and quartering the seived original sample. The subsample was ground with an agate motor and pestle power mill. The bulk of the ground sample would pass through a 100 mesh seive.

The determination of the pH value and the replaceable CaO and MgO contents were made on the original seived air-dried soil.

In the analyses of the soil samples, all determinations were made in duplicate. The individual determinations were reported by laboratory number only. Averages of duplicate determinations were used for reports and discussions. In carrying out the analyses, one series of analyses was made and subsequently this series was replicated. This procedure minimized the possible personal errors and increased the accuracy and value of the averaged data. When the duplicate determinations did not agree aufficiently close to come within the limit of error of the method, the determinations were repeated.

Determination of Hygroscopic Water.

Hygroscopic water was determined by taking 5 g. of the finely ground soil and drying it in an oven at 105° C over night (12 - 18 hours). The time of the drying was controlled within relatively narrow limits. The difference in weight between the original air-dried sample and the sample dried at 105° C gave a rough estimation of the hygroscopic water. The percentage was calculated on the basis of the oven dry soil.

Determination of the Loss on Ignition.

The loss on ignition (L. I.) was determined by igniting the dried sample which had been used for the determination of the hygroscopic water. The ignition was carried out in a muffle furnace at

approximately 1000° C. The difference in weight between the dried sample and the ignited sample gave the loss on ignition which included the organic matter and the combined water of the soil. The percentage was calculated on the basis of the weight of the oven dried soil.

Determination of the Total Nitrogen.

The total nitrogen was determined on a 7 g. sample (14 g. for the sandy soil) of the finely ground soil using the Gunning-Hibbard method. The percentage was calculated on the basis of the weight of the oven-dried soil. (See Methods of Analysis - A. O. A. C., 3rd Edition, (1930) p. 5).

Determination of the Total Carbon.

The total carbon determinations were made on suitably adjusted samples (depending on the organic matter content) of the finely ground soil by the wet combustion method. (See Methods of Analysis A. O. A. C., 3rd Edition (1930) p. 4).

Determination of the Replaceable CaO and MgO.

The determinations of the replaceable CaO and MgO were made by the N. ammonium chloride method which is suitable for soils containing no carbonates. Twenty grams of the original air-dried seived soil were leached with a liter of N. ammonium chloride solution. The replaceable Ca and Mg were determined in the leachate by standard methods. The Ca was determined by the volumetric K Mn O_4 method,

and the Mg by the gravimetric, magnesium pyrophosphate method. The Ca and the Mg were calculated to the percentage of the oxides using the oven-dried soil as a basis.

Determinations of the pH Value of the Soil.

The "reactions" or pH values of the soils were determined on the original air-dried sieved soil. A 1 - 3 soil-distilled water suspension was used in the quinhydrone method.

Analysis of Litter and Duff.

The liter and duff samples were dried in an oven at 100° C. The dry weights were obtained and a representative subsample taken after grinding the entire collected sample. A Quaker mill was used for grinding the litter and duff samples.

The determinations of the loss on ignition, total nitrogen and total carbon were made by the standard methods (virtually the same methods as used for the soil samples) Replaceable CaO and MgO were determined on the duff samples and by the N ammonium chloride method.

Mechanical Analysis.

The following procedure was used for making the mechanical analysis of the soils. The procedure is given in detail because it is not so widely used as the chemical methods are. Fifty grams of fine textured soils, or 100 grams of sand, based on air-dried conditions were placed in a dispersing cup. The cup was filled with

distilled water to about $1\frac{1}{2}$ inches from the top. To the contents, 5 cc. of a solution of saturated and filtered sodium oxalate and 5 cc. of normal sodium hydroxide were added. All soils were allowed to soak for about 15 minutes before dispersing them. The soaking was done in a separete vessel and the material was then washed into the cup. The cup was then connected to the stirring motor and the contents stirred for 5 minutes in the case of sands, and 10 minutes in the case of other soils. Sands should not be stirred more than 5 minutes because they seem to undergo grinding. After stirring, the contents were poured and washed into the special cylinder. If 50 grams of soil were used, the cylinder was filled to the lower mark with the hydrometer in it. If 100 grams were used it was filled to the upper mark with the hydrometer in it. Only distilled water was used. The hydrometer was taken out, the palm of the hand placed on the mouth of the cylinder and the contents shaken thoroughly by turning the cylinder upside down and back several times. The cylinder was quickly placed on the table and the time noted immediately. At desired periods the hydrometer was put in the suspension, the reading recorded and it was then taken out again. At each hydrometer reading the temperature of the suspension was measured in order to make corrections for temperature. Care was taken not to disturb the suspension in putting in and taking out the hydrometer and the thermometer.

The different sized fractions were calculated from the hydrometer readings and expressed as percentage of the original air-dried soil. (See Bouyoucos: Jr. Am. Soc. Agro. V. 23, No. 4, p. 747-751 (1930).

Unburned 45 years
No. 274840

Burned annually
Area 2, Bartow, Polk Co., Fla.
(April, 1932)
No. 274846

Unburned 15 years. Longleaf pine.
(October, 1931)
No. 264153)

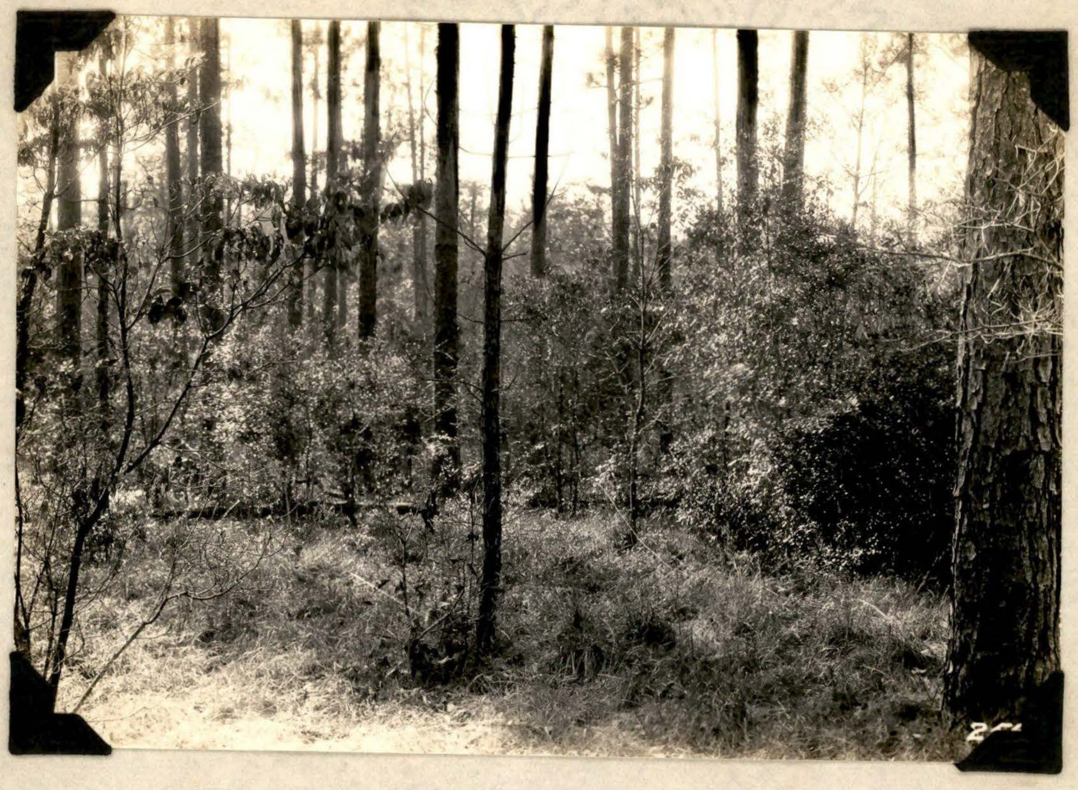
Burned annually
Area 3, Trenton, Gilchrist Co. Fla.
(October, 1931)
No. 264150

Unburned for 12-15 years except for a light night fire in March, 1929.
(March, 1931)
No. 254961

Burned annually. Area 9, Ridgeland, S. C.
(March, 1931)
No. 254903.

Unburned 38 years
(March, 1931)
No. 25989

Burned Biannually
Area 10, Cowhouse Island, Okefenokee Swamp, Ga.
(March, 1931)
No. 255685



Unburned 20 -25 years. Culled over longleaf pine
Harrison County, Miss.
(December, 1930)
No. 256529

Annually burned area comparable to unburned area above
(December, 1930)
No. 256531.

Unburned 17 years
(November, 1931)
No. 264182

Burned annually
Area 14, Urania, La.
(November, 1931)
No. 264186

DESCRIPTIONS OF LONG UNBURNED AREAS FROM WHICH SOILS WERE COLLECTED.

Area No. 1. About 1 mile west of Camp Pinchot, Choctawhatchee National Forest, Okloosa County, Florida.

Arbitrary Soil Class: Excessively drained deep sands.

Soil Designation: Norfolk sand.

Topography : Level.

Forest Type: Longleaf pine - turkey oak.

Date of Collection: April 12, 1931.

Unburned Area

Extent: ¼ Acre.

Fire History: Unburned since 1908.

Vegetative Cover: Sparse stand of old growth longleaf pine with heavy understory of turkey and blue-jack oaks. Sparse herbaceous vegetation.

Litter and Duff: Litter present in thin scattered patches of wind shifted oak leaves and few pine needles. No duff.

Burned Area

Fire History: Frequently burned at irregular intervals and annually as a fire line for past 4 years.

Vegetative Cover: Same as that of the unburned area except fewer longleaf pines and heavier stand of turkey oak.

Litter and Duff: Patches of wind shifted turkey oak leaves. No duff.

Proximity to Unburned Area: About $\frac{1}{2}$ mile distant.

Livestock: Both burned and unburned areas open to grazing but the small amount of browse does not encourage the presence of cattle.

****

Area No. 2: Property of C. E. Stuart, 3 miles south of Bartow, Fla. on the Ft. Meade road, Polk County,

Arbitrary Soil Class: Excessively drained deep sands.

Soil Designation: Ft. Meade fine sand.

Topography: Five percent ( ) slope to north.

Forest Type: Longleaf pine.

Date of Collection: March 23, 1931

Second Collection: April 20, 1932.

Unburned Area

Extent: 10 acres.

Fire History: Unburned since 1888.

Vegetative Cover: Open stand of virgin longleaf pine with dense undergrowth of vines and hardwoods. Commonest vines: Virginia creeper, poison

--ivy, wild grape, and a few bamboo-briar. Common hardwoods: laurel oak, live oak, and wild cherry.

<u>Litter and Duff:</u> Well mixed pine needles and hardwood leaves, particularly leaves of the vines mentioned, up to 1½ inches deep.

<u>Burned Area</u>

<u>Fire History:</u> Burned practically every year.

<u>Vegetative Cover:</u> Sparse stand of pine being worked for turpentine. The timber had been culled over many years ago. No hardwoods. Light ground cover of herbaceous plants.

<u>Litter and Duff:</u> Sparse litter and no duff.

<u>Proximity to Unburned Area:</u> Separated only by a paved highway.

<u>Livestock:</u> Burned area open to grazing while unburned under fence.

* * * * * * *

<u>Area No. 3:</u> Property of R. C. Williams, 1 mile east of Trenton, Gilchrist County Florida.

<u>Arbitrary Soil Class:</u> Well drained sands.

<u>Soil Designation:</u> Blanton sand.

<u>Topography:</u> Very small slope (2-4 percent) to east.

<u>Forest Type:</u> Longleaf pine.

Date of Collection: October 26, 1931.

Second Collection: August 30, 1932.

Unburned Area

Extent: 120 acres.

Fire History: Unburned 15 - 20 years.

Vegetative Cover: Most of the old growth timber destroyed by "blowdown" of 1896. Present stand is partially stocked second growth longleaf pine, about 27 years old. (140 trees per acre 1" d.b.h. and over based on one acre plot.) Timber patchy being dense in spots and very open in others. Soils collected from densest portions of stand. Bluejack oaks abundant as well as saw palmetto. Abundate wire grass.

Litter and Duff: Under densest stands, 2 inches deep.

Burned Area

Fire History: Burned frequently.

Vegetative Cover: Second growth longleaf pine 185 trees per acre 1 inch d.b.h. and over (based on one acre sample plot). Abundant bluejack oak, but few palmetto, and

abundant dogfennel. Herbaceous ground cover of wide variety of plants.

Litter and Duff: $\frac{1}{2}$ - $\frac{1}{3}$ " litter and no duff.

Proximity to Unburned Area: Separated by woods road.

Livestock: Both burned and unburned grazed, the latter heavily.

* * * * * * * * *

Area No. 4: Property Mr. Mixon, $\frac{1}{2}$ mile west of Lake City. Columbia County, Florida, on U. S. Highway No. 90.

Arbitrary Soil Class: Well drained sands.

Soil Designation: Blanton Fine sand

Topography: Level.

Date of Collection: December 17, 1931.

Unburned Area

Extent: 20 acres

Fire History: Unburned at least 12 years.

Forest Type: Longleaf-loblolly on old field last cultivated about 45 years ago.

Vegetative Cover: Dense ground cover of yellow jessamine. Fewer hardwoods than typical of unburned areas as goats pastured here for several tears. Few scattered laurel oaks.

Litter and Duff: Difficult to estimate because of dense carpet of jessamine.

STAND TABLES FOR BURNED AND UNBURNED AREAS. TRENTON, FLORIDA

BASED ON 2 ONE - ACRE PLOTS.

Unburned

	Longleaf Pine		Blackjack Oak		Southern Red Oak		Wild Cherry		Slash Pine		Dwarf Sumach		Wax Myrtle		Persimmon		Saw Palmetto	
Grass	Burn	Unb.	Burn.	Unb.	Burn	Unb.	Burn	Unb.	Burn	Unb	Burn	Unb	Burn	Unb	Burn	Unb	Burn	Unb
Stage	7	11																
3-6 ft	10	5	30															
1"	12	3	12	1														
2"	15	28	28	14														
3"	12	21	24	13														
4"	10	22	12	14														
5"	8	27	7	8														
6"	13	22	5	2														
7"	17	24	3	5														
8"	15	17	2															
9"	13	12	1															
10"	10	3																
11"	4	0																
12"	1	0																
Veterans	1	1																
Total	148	196	124	71	3	0	5	0	1	0	16	0	2	0	0	1	50	19

Burned Area

Fire History: Burned frequently.

Forest Type: Old field longleaf. Last under cultivation 35 (?) years ago.

Vegetative Cover: Same high forest in general as that on unburned. Varied ground cover of wide variety herbs.

Litter and Duff: Sparse litter and no duff.

Proximity to Unburned Area: About 100 yards distant and nearer a swamp. Drainage good at location where samples collected.

Livestock: Open range on burned. Unburned under fence.

* * * * * * * * * * *

Area No. 5 Property J. H. Spivey, vicinity Soperton, Johnson Co. Georgia.

Arbitrary Soil Class: Well drained sands.

Soil designation : Ruston sand.

Topography: 5 percent ( ) slope to the south on unburned and 2 percent ( ) slope to north on burned. These two areas separated by a foot intermittent stream that flows during wet weather only

Forest Type: Longleaf pine.

Date of Collection: February 12, 1931.

Second Collection: May 24, 1932.

Unburned Area

Extent: 5 acres.

Fire History: Unburned 15 years.

Vegetative Cover: Very dense second growth longleaf about 1100 trees per acre. Stand 24 years old. No ground cover except wire grass in spots.

Litter and Duff: $1\frac{1}{2}$" - $2\frac{1}{2}$".

Burned Area

Fire History: Burned every 2 or 3 years during past 15 years for pasture.

Vegetative Cover: Open stand of longleaf, 250 trees per acre. Varied herbaceous vegetation, abundant broom sedge.

Litter and Duff: Sparse litter and no duff.

Proximity of Unburned Area: Adjacent.

Livestock: Both areas open to grazing.

* * * * * * * * * * *

Area No.6 See page 73-a

Area No. 7: Fire plots of Southern Forest Exp. Station, Raiford Prison Farm, Raiford, Bradford County, Florida.

Arbitrary Soil Class: Moist sands.

Soil Designation: Blanton fine sand.

Topography: Level.

Area No. 6 Property being turpentined by Mr. Falk, vicinity of Chipley, Washington County, Florida.

Arbitrary Soil Class: Moist sands.

Soil Designation: Norfolk fine sand

Topography: 3 percent slope to west.

Forest type: Longleaf pine

Date of Collection: November 9, 1931.

Unburned Area

Extent: 10 acres.

Fire History: Unburned except for 1 light fire during last 15 years. (This area was burned the week following the present field work).

Vegetative Cover: Well stocked stand of second growth longleaf about 25 years old. Ground cover of wire grass and abundant blackberry.

Litter and Duff: None in openings in stand but 1" - $1\frac{1}{2}$" deep under dense portions.

Burned Area

Fire History: Burned frequently.

Vegetative Cover: Same high forest as that on unburned but varied ground cover of herbaceous plants.

Litter and Duff: Sparse litter and no duff.

Proximity to Unburned Area: Adjacent

Livestock: Both areas open to grazing.

Forest Type: Longleaf - loblolly pine.

Date of Collection: December 15, 1931.

Unburned Area

Extent: 1/4 acre.

Fire History: Unburned for 9 years.

Vegetative Cover: About 300 trees, 25 years old, per acre. Sparse ground cover of blackberry and few scattered herbs.

Litter and Duff: 1" - 1½" thick.

Burned Area

Vegetative Cover: Because of closed stand only sparse ground cover herbs.

Litter and Duff: Small amount of litter and no duff.

Proximity to Unburned Area: Adjacent.

Livestock: None present.

* * * * * * * * * * *

Area No. 8: Carnegie Estate, Mr. MacLaurin, Supt. Cumberland Island, Georgia (Off Georgia Coast just north of Fernandina.)

Arbitrary Soil Class: Moist sands.

Soil Designation: Norfolk fine sand.

Topography: Level

Forest Type: Longleaf pine.

Date of Collection: December 4, 1931.

Unburned Area

Extent: 5000 acres.

Fire History: Unburned at least 40 years and probably for much longer.

Vegetative Cover: Because of the long protection the hardwoods usually found as a high underbrush on protected areas were present as a distinct understory 20-30 feet high and many laurel and live oaks were codominant trees in the high forest. Saw palmetto in impenetrable growths 10 ft. tall were found. Wax myrtle, highbush huckleberry, red bay, swamp bay, holly, and devilwood common. High forest was heavy stand of virgin longleaf pine.

Litter and Duff: $1\frac{1}{2}$" to 2" thick.

Burned Area

None found.

* * * * * * * * * *

Area No. 9: Savannah Hill Number 1. Chelsea Club, Ridgeland, Jasper County, South Carolina.

Arbitrary Soil Class: Moist sands.

Soil Designation: Norfolk fine sand.

Topography: Level.

Forest Type: Loblolly pine - hardwoods.

Date of Collection: February 4, 1931.

Unburned Area

Extent: 5 acres.

Fire History: Only one fire during the past 12 or 15 years and this a light early morning burn March, 1929, which remeoved the litter and duff, killed most of the gallberry, but hardly scorched the timber.

Vegetative Cover: Virgin loblolly pine with codominant and intermediate hardwoods of following species: red gum, southern red oak, live oak, water oak, and shortleaf pine. Abundant wax myrtle in sparse clumps, No ground cover or herbaceous plants.

Litter and Duff: Only a small amount of litter present as only a two year's accumulation and no duff.

Burned Area

Fire History: Burned annually as part of game management plan.

Vegetative Cover: Open stand of loblolly pine and no hardwoods or underbrush. Heavy ground cover of herbaceous plants a large number of which were legumes.

Litter and Duff: Only 1 year's fall of pine needles as litter and no duff.

Proximity to Unburned Area: ½ mile distant

Livestock: Both areas open to grazing. Unburned area probably more moist than burned. This indicated by presence of hardwoods on unburned. These could hardly have been completely removed by even annual fires. These areas are not, therefore, strictly comparable.

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Area NO. 10. Property Lydia Crews, Cowhouse Island, Okefenokee Swamp, vicinity Racepond, Charlton County, Georgia.

Arbitrary Soil Class: Poorly drained sands.

Soil Designation: Leon fine sand.

Topography: Flat.

Forest Type: Longleaf - slash pine

Date of Collection: February 20, 1931.

Unburned Area

Extent: 5 acres

Fire History: Unburned 38 years.

Vegetative Cover: Heavy stand of 38 year old mixed Longleaf and slash, 300-320 trees per acre Very dense underbrush of saw palmetto,

4-6 feet tall and scattered gallberry, laurel oak, red bay, sweet bay, Virginia willow, sparkleberry, and nannyberry. The oaks and bays up to 2" d.b.h. and 20 feet tall. Also wild grape vines in abundance.

Litter and Duff: 2" - $2\frac{1}{2}$" deep.

Burned Area

Fire History: No fires between 1893 and 1919 but burned biannually since then.

Vegetative Cover: Same high forest as that on unburned but no hardwoods as underbrush. Abundant ~~g~~ gallberry and palmetto about 18 inches tall.

Litter and Duff: Two years accumulation of litter, $\frac{1}{4}$" to $\frac{1}{2}$" in places, and no duff.

Proximity to Unburned Area: Adjacent.

Livestock: Unburned, too dense for cattle to penetrate while burned is used for pasture.

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Area No. 11: Property Mr. Thrift, Suwannee Lake, Okefenokee Swamp, 18 miles southwest of Waycross, Ware County, Georgia.

Arbitrary Soil Class: Poorly drained sands.

Soil Designation: Leon fine sand.

Topography: Flat.

Forest Type: Slash pine.

Date of Collection: February 23, 1931.

Unburned Area

Extent: $\frac{1}{5}$ acre.

Fire History: Unburned 15 - 20 years.

Vegetative Cover: Dense stand of 15 year old slash pine. Underbrush of scattered gallberry and palmetto, and ground cover of wire grass where litter not too thick.

Litter and Duff: 2" - $2\frac{1}{2}$" thick.

Burned Area

Fire History: Burned frequently

Vegetative Cover: Few scattered slash pines probably not more than 10 to the acre. Heavy stand of grasses and other herbs.

Litter and Duff: None present

Proximity to Unburned Area: Adjacent.

Livestock: Both area open to grazing.

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Area No. 12: Property B. S. Edwards. vicinity Starke, Bradford County, Fla.

Arbitrary Soil Class: Poorly drained sands.

Soil Designation: Portsmouth fine sand.

Topography: Practically level.

Forest Type: Slash Pine.

Date of Collection: January 21, 1931

Unburned Area

Extent: 5 acres.

Fire History: Unburned for 12 - 15 years.

Vegetative Cover: Second growth slash pine 8 - 15 years old, uneven aged, and dense undergrowth of hardwoods most common of which is gallberry followed by saw palmetto, laurel oak, live oak, water oak, red maple, red bay, and sweet bay. Heavy stands of wire grass in openings in timber.

Litter and Duff: $1\frac{1}{2}$" - 2" under closed portions of stand.

Burned Area

Fire History: Burned frequently

Vegetative Cover: Few scattered old growth slash and longleaf pines. No underbrush but dense ground cover of herbaceous plants.

Litter and Duff: None present.

Proximity to Unburned Area: Adjacent

Livestock: Both areas open to grazing.

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Area No. 13: Fire and grazing Plots, property leashed by the Southern Forest Experiment Station, Location: McNeil, Pearl River County, Mississippi.

Arbitrary Soil Class: Well drained sandy laoms.

Soil Designation: Orangeburg fine sandy loam.

Topography: 3 percent slope to east.

Forest Type: Longleaf pine.

Date of Collection: November 5, 1931.

Second Collection: May 14, 1932.

Unburned Area

Extent: 10 acres

Fire History: Unburned past 8 years.

Vegetative Cover: Open patchy stand of longleaf second growth. Heavy rough of wire grass.

Litter and Duff: 1" - 1½" thick under densest portions of stand.

Burned Area

Fire History: Burned annually last 8 years and frequently prior to this.

Vegetative Cover: Stand of timber same in general as that of unburned. Appear to be wider variety of plants comprising the dense ground cover than on unburned.

Litter and Duff: 1 year's accumulation of litter and no duff.

Proximity to Unburned Area: Adjacent.

Livestock: None on either area.

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Area No. 14: Roberts Plots of the Southern Forest Exp. Station, Urania, LaSalle Parish, Louisiana.

Arbitrary Soil Class: Medium drained silt loam.

Soil Designation: Caddo ( ) silt loam.

Topography: Level.

Forest Type: Longleaf pine.

Date of Collection: November 3, 1931.

Unburned Area

Extent: ¼ acre

Fire History: Unburned since 1915.

Vegetative Cover: Heavy stand of 18 year old longleaf pine with mixture of loblolly and of the following hardwoods: red gum, dwarf sumach, southern red oak, wax myrtle, red maple, holly, wild cherry, sparkleberry, hawthorne and azalea. No ground cover.

Litter and Duff: 1" - 1½" deep.

Burned Area

Fire History: Burned annually since 1915.

Vegetation: Less dense stand of longleaf pine, no loblolly, and none of the hardwoods found on unburned except wax myrtle and little sumach. Abundant blackjack oak.

Litter and Duff: Sparse litter and no duff.

Proximity to Unburned Area: Adjacent.

Livestock: None

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Area No. 15: Fire Plots of Appalachian Forest Experiment Station at Clemson Coast Experiment Station, Summerville, Orangeburg County, South Carolina.

Arbitrary Soil Class: Poorly drained fine sandy loam.

Soil Designation: Norfolk fine sandy loam.

Topography: Level.

Forest Type: Longleaf pine.

Date of Collection: February 6, 1931.

Unburned Area

Extent: $\frac{1}{4}$ acre

Fire History: Unburned since 1917 but frequently prior to this date.

Vegetative Cover: Somewhat patchy stand of 20-25 year old longleaf and also a few slash. Abundant blackberry and wire grass, and little broom sedge.

Litter and Duff: 2" - $2\frac{1}{2}$" litter under closed portions of stand.

Burned Area.

Fire History: Burned annually since 1917 and frequently prior to this date.

Vegetative Cover: Same stand of pine as that on unburned but no slash. Dense ground cover of wire grass, broom straw and various other herbs.

Litter and Duff: Only 1 year's litter present and no duff.

Proximity to Unburned Area: Adjacent.

Livestock: None.